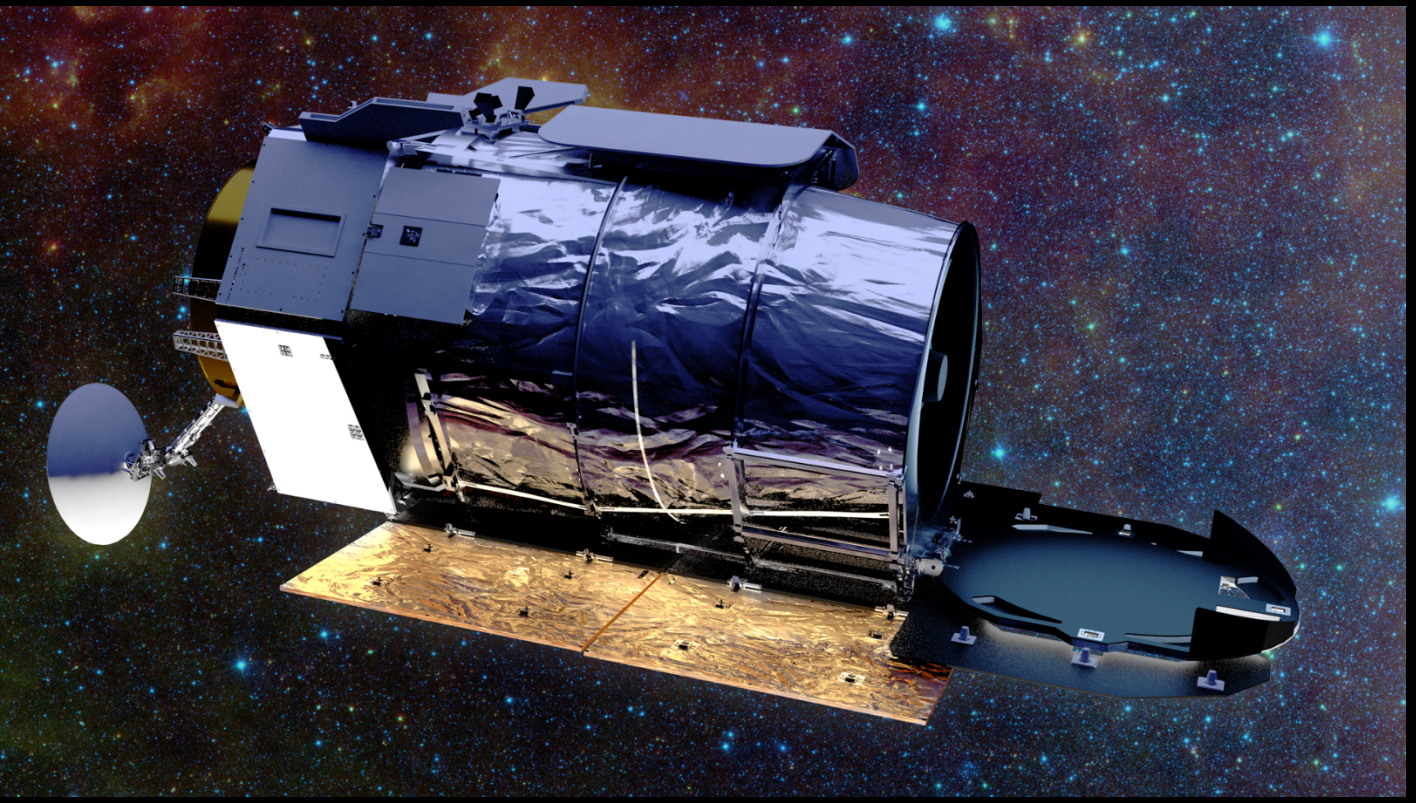
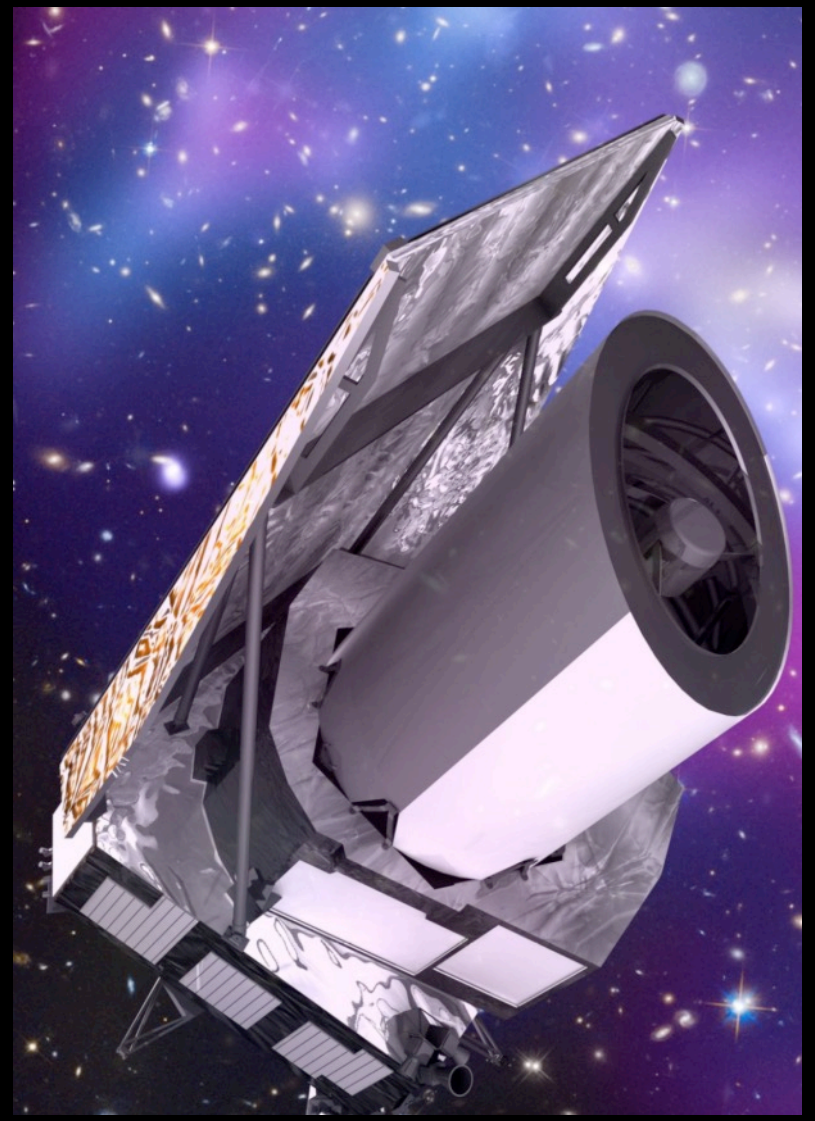
LSST Synergy With Euclid and WFIRST





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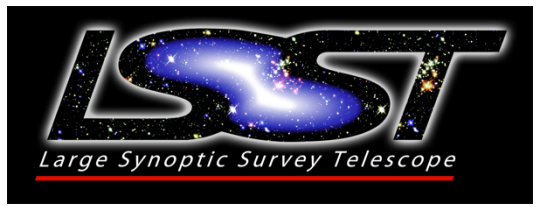
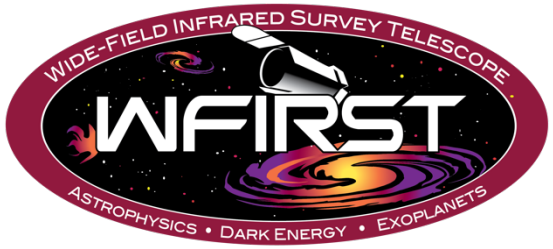
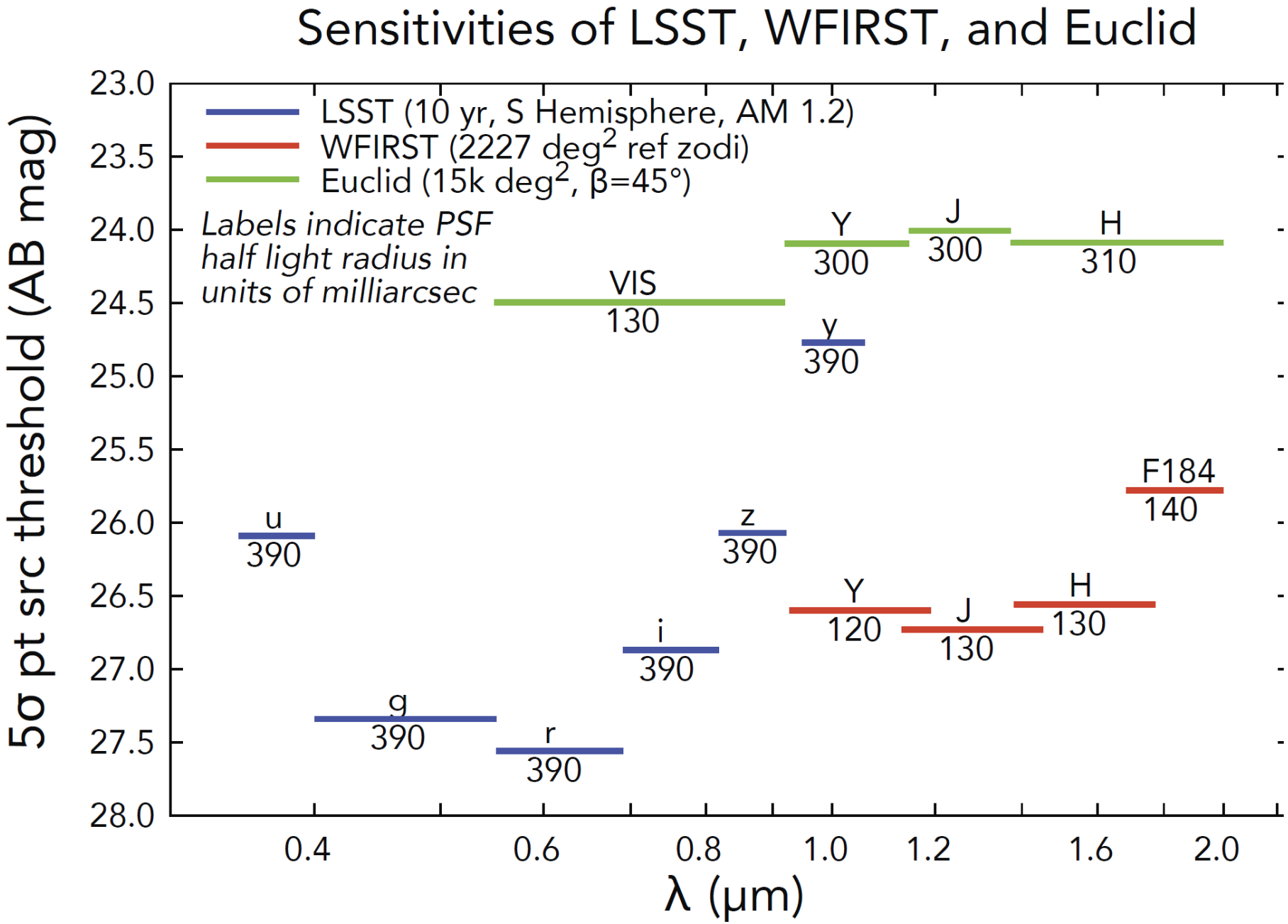
May 21, 2019





Proposed lifetime	2022 - 2032	2022 - 2028	2025 - 2031
Mirror size (m)	6.5 (effective diameter)	1.2	2.4
Survey size (sq deg)	20,000	15,000	2,227
Median z (WL)	0.9	0.9	1.2
Depth (AB mag)	~27.5	~24.5	~27
FoV (sq deg)	9.6	0.5 (Vis) 0.5 (NIR)	0.28
Filters	u-g-r-i-z-y	Y-J-H-Vis	Y-J-H-F184
Cosmological probes	WL, LSS, SN	WL, LSS	WL, LSS, SN


Sensitivities of LSST, WFIRST, and Euclid
LSST (10 yr, S Hemisphere, AM 1.2)
WFIRST (2227 deg^2 ref zodi)
Euclid (15k deg^2, β=45°)
Labels indicate PSF half light radius in units of milliarcsec
u 390
g 390
r 390
i 390
z 390
y 390
VIS 130
Y 300
J 300
H 310
F184 140
Y 120
J 130
H 130
5σ pt src threshold (AB mag)
23.0
23.5
24.0
24.5
25.0
25.5
26.0
26.5
27.0
27.5
28.0
0.4
0.6
0.8
1.0
1.2
1.6
2.0
λ (μm)

Synergy papers: The whole is more that the sum of the parts

The Whole is Greater than the Sum of the Parts: Optimizing the Joint Science Return from LSST, Euclid and WFIRST

Jain, Spergel, et al 2015

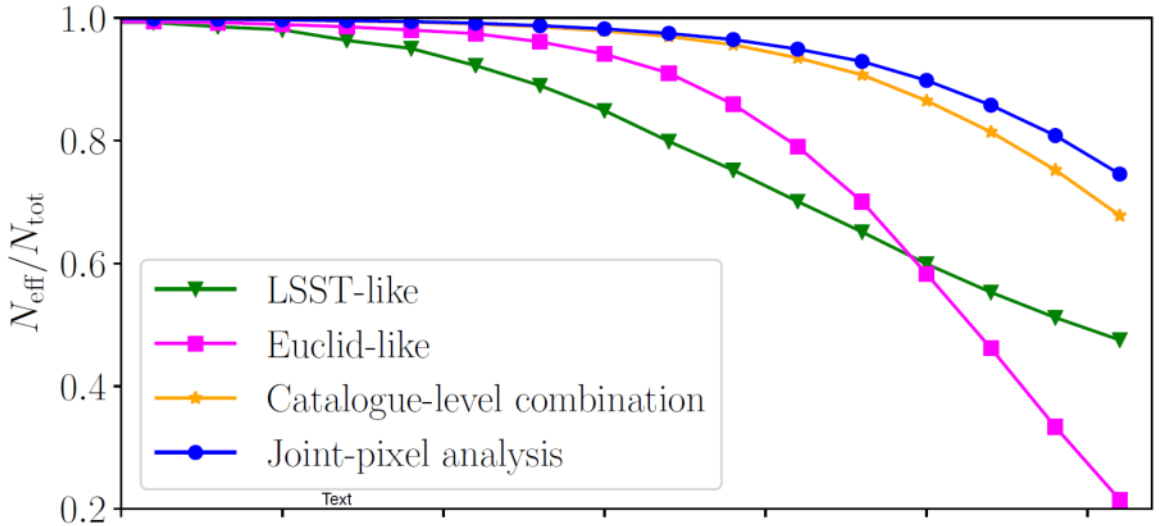
The focus of this report is on the opportunities enabled by the combination of LSST, Euclid and WFIRST, the optical surveys that will be an essential part of the next decade's astronomy. The sum of these surveys has the potential to be significantly greater than the contributions of the individual parts. As is detailed in this report, the combination of these surveys should give us multi-wavelength high-resolution images of galaxies and broadband data covering much of the stellar energy spectrum. These stellar and galactic data have the potential of yielding new insights into topics ranging from the formation history of the Milky Way to the mass of the neutrino. However, enabling the astronomy community to fully exploit this multi-instrument data set is a challenging technical task: for much of the science, we will need to combine the photometry across multiple wavelengths with varying spectral and spatial resolution. We identify some of the key science enabled by the combined surveys and the key technical challenges in achieving the synergies.

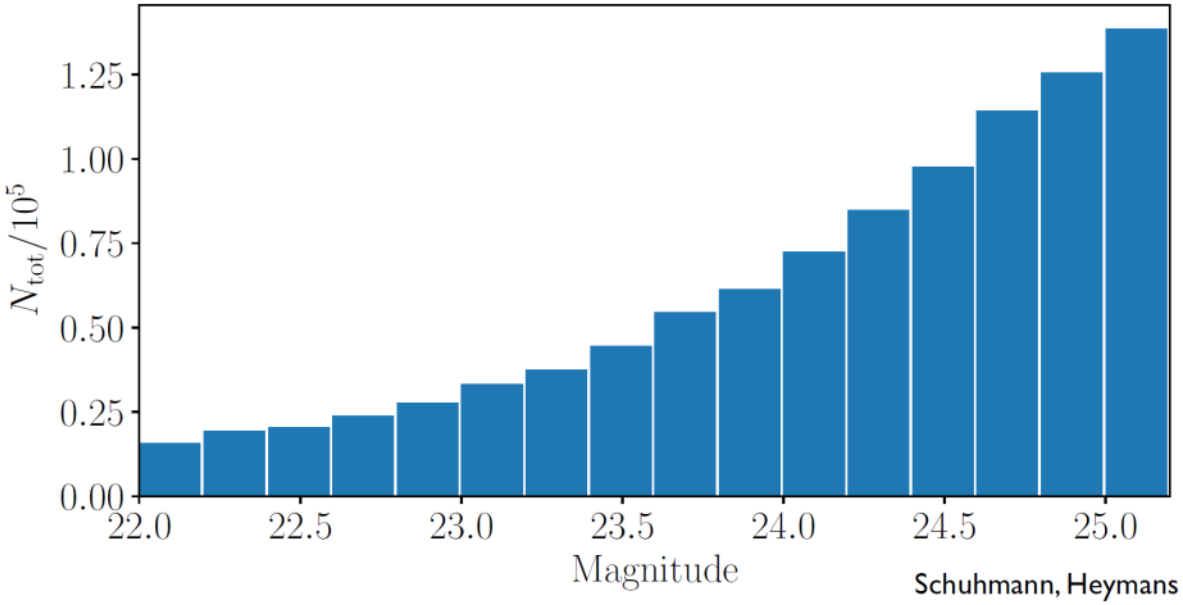
Scientific Synergy between LSST and *Euclid*

Rhodes, Nichol, et al 2017

Euclid and the Large Synoptic Survey Telescope (LSST) are poised to dramatically change the astronomy landscape early in the next decade. The combination of high-cadence, deep, wide-field optical photometry from LSST with high-resolution, wide-field optical photometry, and near-infrared photometry and spectroscopy from *Euclid* will be powerful for addressing a wide range of astrophysical questions. We explore *Euclid*/LSST synergy, ignoring the political issues associated with data access to focus on the scientific, technical, and financial benefits of coordination. We focus primarily on dark energy cosmology, but also discuss galaxy evolution, transient objects, solar system science, and galaxy cluster studies. We concentrate on synergies that require coordination in cadence or survey overlap, or would benefit from pixel-level co-processing that is beyond the scope of what is currently planned, rather than scientific programs that could be accomplished only at the catalog level without coordination in data processing or survey strategies. We provide two quantitative examples of scientific synergies: the decrease in photo-*z* errors (benefiting many science cases) when high-resolution *Euclid* data are used for LSST photo-*z* determination, and the resulting increase in weak-lensing signal-to-noise ratio from smaller photo-*z* errors. We briefly discuss other areas of coordination, including high-performance computing resources and calibration data. Finally, we address concerns about the loss of independence and potential cross-checks between the two missions and the potential consequences of not collaborating.

Benefits for Shear Measurement



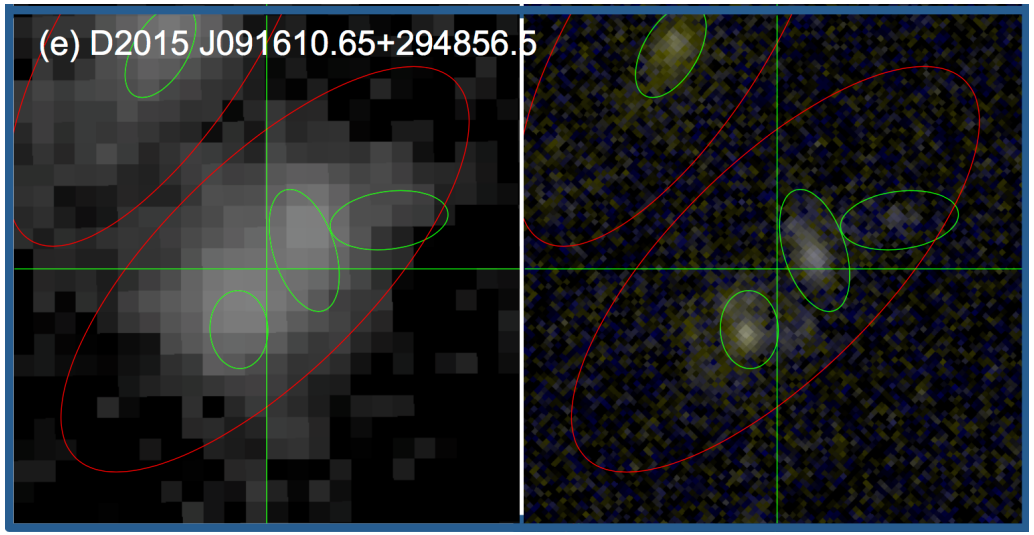


- number of useful galaxies for shear estimation as a fraction of total galaxies
- Lowe limit of gains of joint processing at pixel level
  - Further improvement expected from deblending
  - Further improvement expected from star/galaxy separation

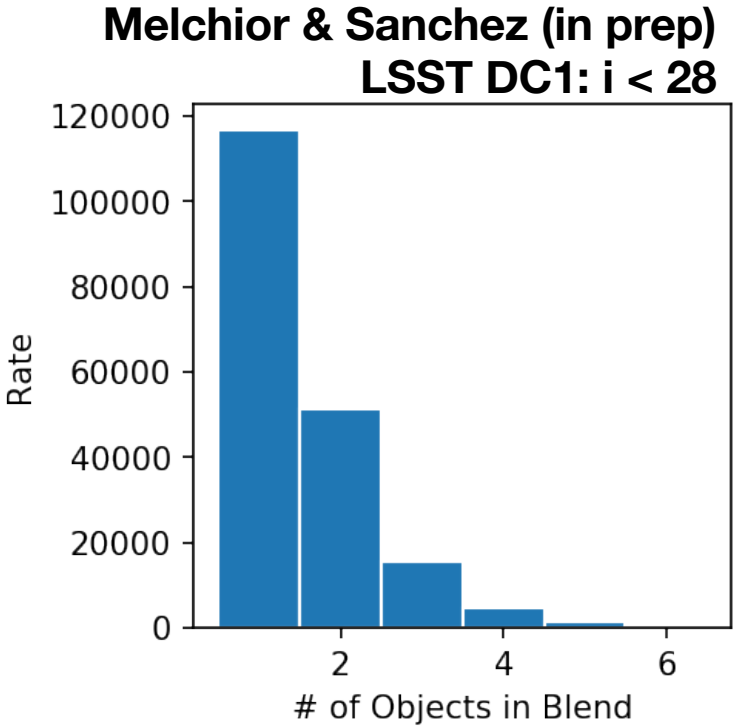
- Full power of cosmic shear in ~2030 will make use of data from all thee surveys simultaneously

Schuhmann, Heymans and Zuntz 2019

Blending is Trouble



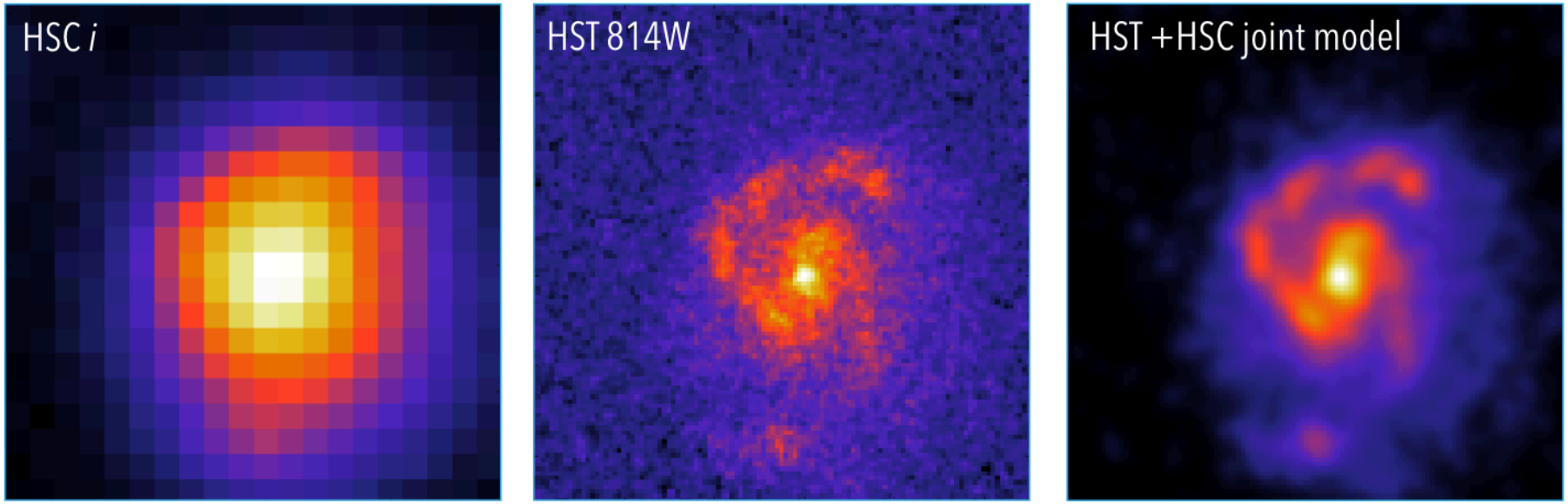
Dawson et al. (2016): LSST-like Subaru data



- Blending is abundant (>50%) and problematic
- Affects photometry and shapes at the several percent level
- 15% to 20% of the cases undetected in ground-based images

Joint Pixel-level Processing

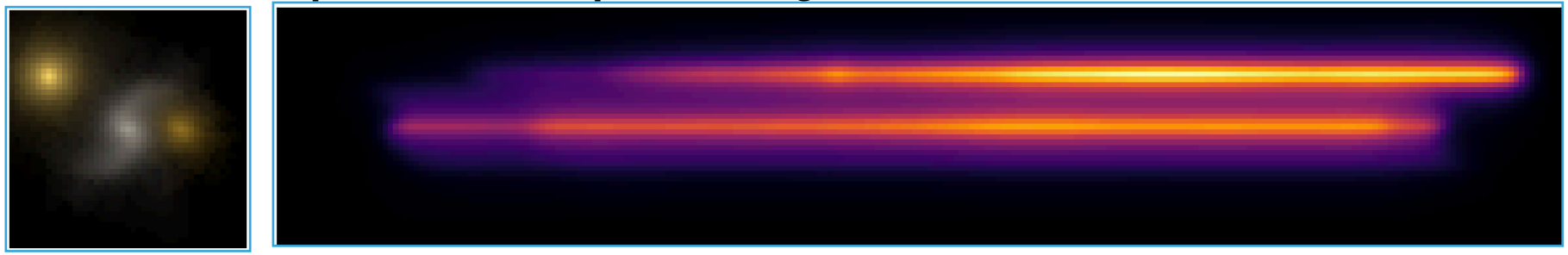
Fine details and multiple detections from multi-resolution image analysis



R. Joseph (Princeton)

Characterization and Source Separation from spectral range and resolution

Grism spectroscopy can further help with dedblending



simulated R=200 grism VIS - IR

P. Melchior (Princeton)

US Tri-Agency (NSF/DOE/NASA) Efforts

- All efforts have European Euclid participation

- Survey Coordination: **Peter Capak and Daniel Scolnic** co-leads
  - Led to LSST survey optimization white papers
  - Community consensus on northern extension and deep field location
  - Asian telescope assets in deep fields critical!

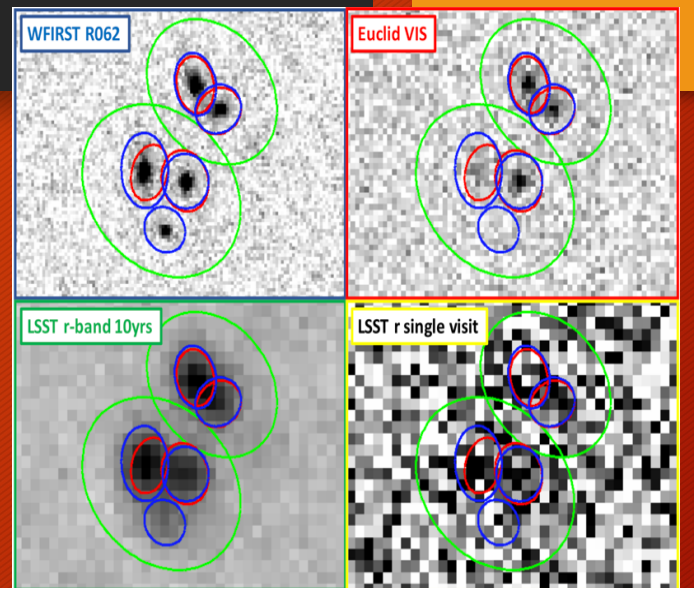
- Joint Pixel Level Processing **Ranga Ram Chary and George Helou** co-leads
  - Scoped out joint pixel level processing beyond what any of the three missions already plan
  - See also work by **Hironao Miyatake** work on HSC/HST as precursor to LSST/WFIRST

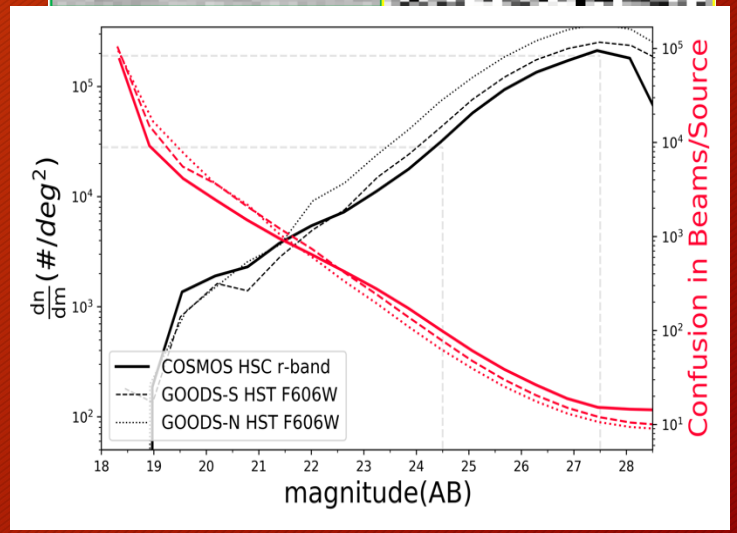
- Cosmological Simulations and high performance computing coordination co led by **Alina Kiessling and Katrin Heitmann**
  - Same universe; we don't need to simulate it three times!
  - Sharing of simulations and coordination of simulation campaigns

Joint Survey Processing:

Precision astrometry and deconfusion ➔ precise photometry➔precise phot redshifts➔precise cosmology

- An IPAC-led (Helou & Chary) tri-agency initiative to optimally combine LSST, Euclid and WFIRST data sets at the pixel level enabling precise cosmology and new astrophysics science
- Building prototype based on Hubble/ACS and Subaru/HSC data in COSMOS (Thanks to Hironao and NAOJ folks) with a goal of 10mas astrometry and 10millimag phot. calibration
- Source confusion is a serious hindrance to precision photometry in deep ground-based data!





Summary

- Have emphasized cosmology here but benefits go beyond
  - Time domain, anything with photo-z, solar system, etc.

- US agencies recognize need for coordination and benefits of joint processing and analysis
  - Ongoing efforts encourage involvement of all eligible groups

- Ancillary data, especially in deep fields will be critical to core and legacy science

- Contact me if you want some advice on getting involved

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